Up-to-date Cosmic Ray Applications for a SSA Satellite, for SWON, in ViSpaNet and for Fukushima radiation

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1) Cosmic Ray Imaging Telescope and Medipix Detector

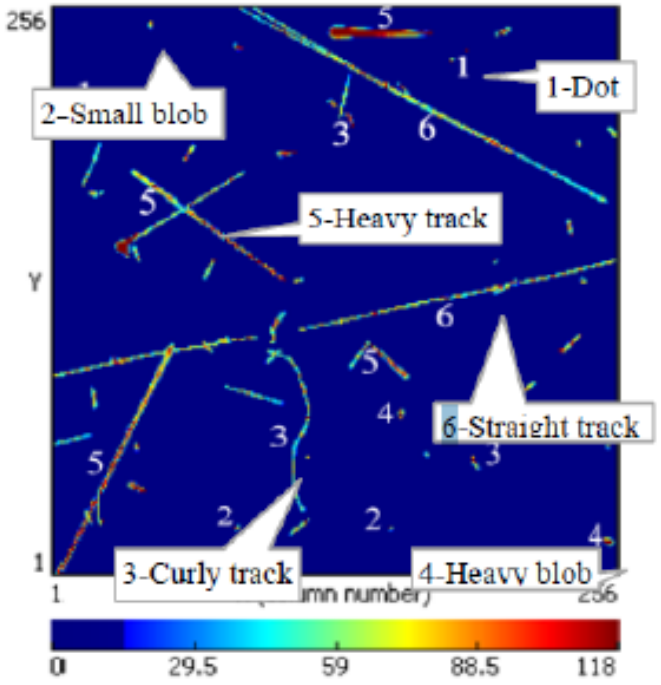
2) SWON – Space Weather Observation Network

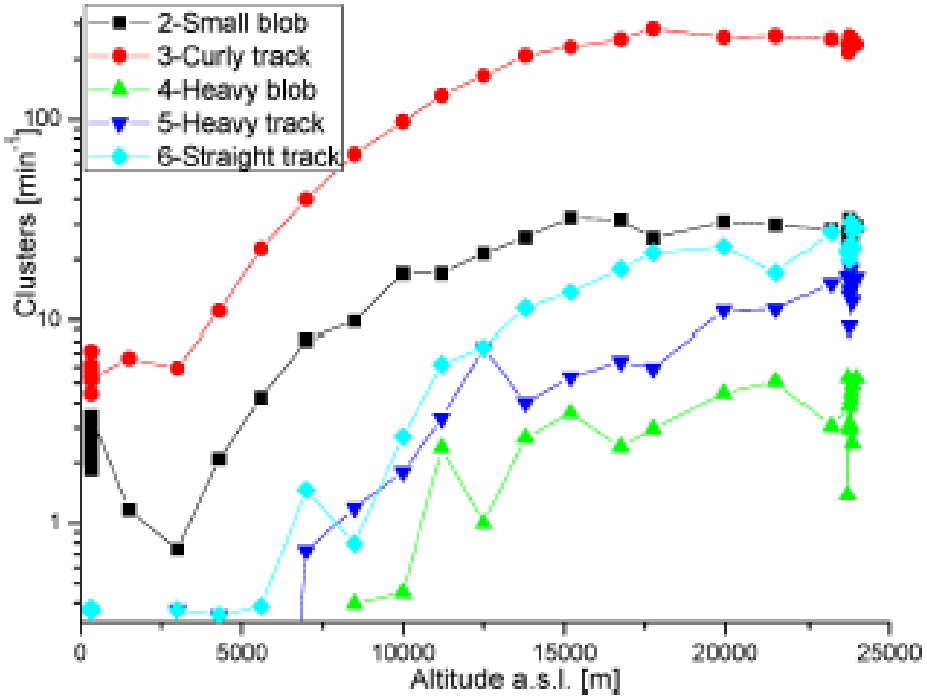
3) ViSpaNet (Virtual Space weather Network of space systems)

4) GMDN data, solar maximum and Fukushima radiation

1) COSMIC RAY IMAGING TELESCOPE and Medipix DETECTOR

BEXUS / Medipix ballon flight (J. Urbar)



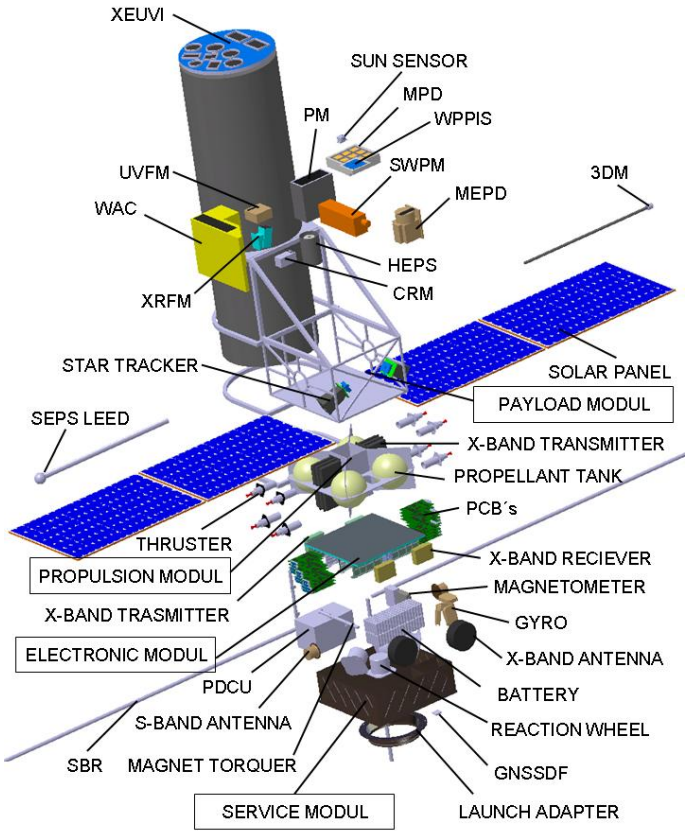


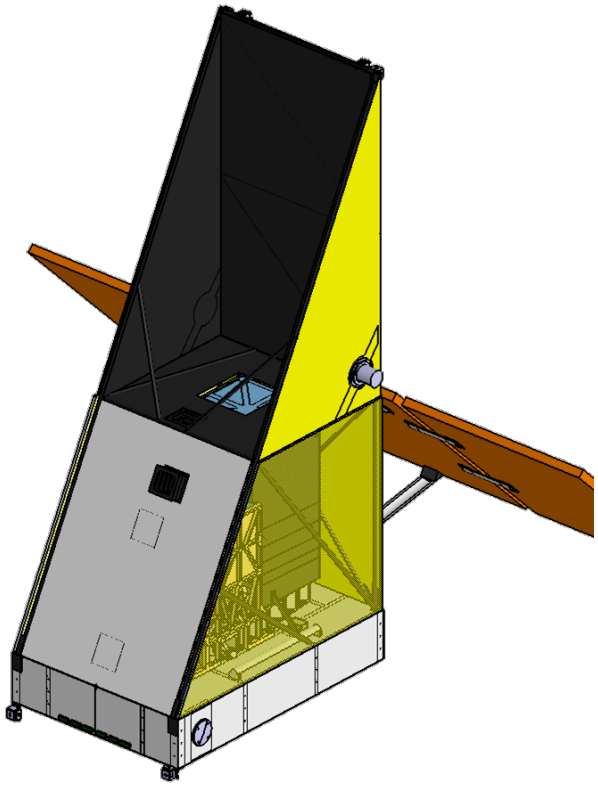
1 X-rays & low energy electrons
2 gamma and & electrons
3 high energy electrons
4 short range ions
5 long range ions
6 massive interacting particles

1) COSMIC RAY IMAGING TELESCOPE and Medipix DETECTOR

- Proposal for a SSA (Space Situational Awareness) satellite + DLR Bremen AF for NEOs (Phase B)

- This space weather and space debris orientated SSA satellite is proposed to have all necessary electromagnetic wave, particle and imaging instruments and telescopes.

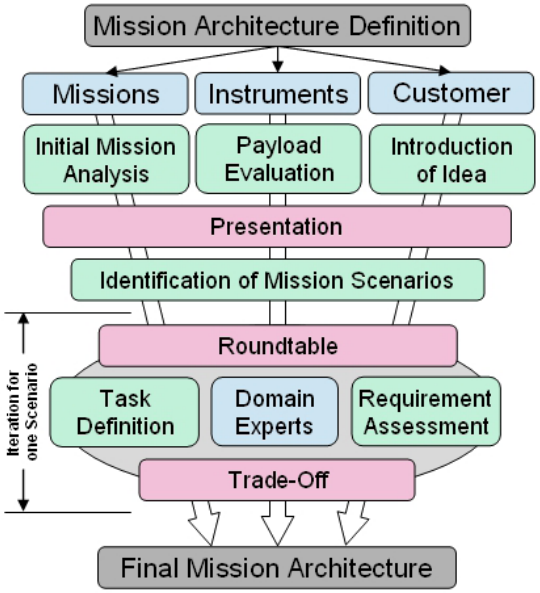


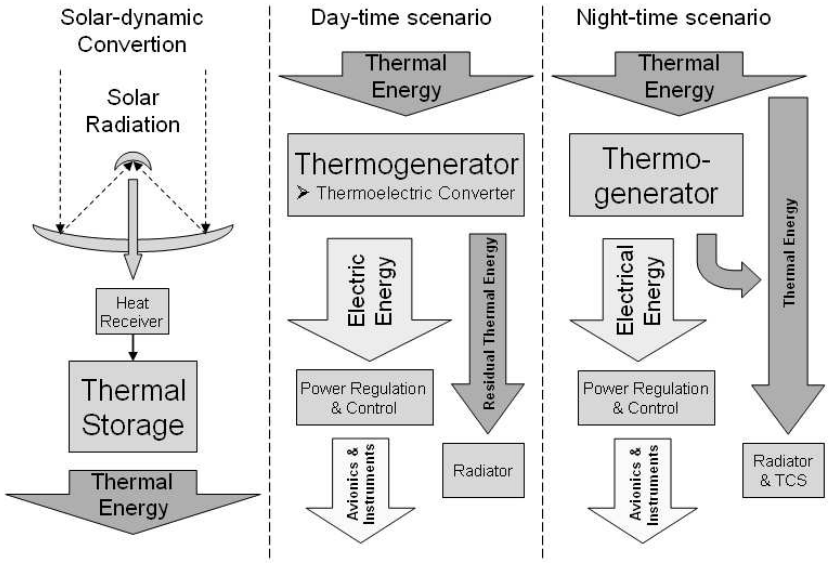


2) SPACE WEATHER OBSERVATION NETWORK (SWON)

- combining solar & asteroid science with space weather: **landing with a fleet of s/c on asteroid (IEO) behind the Sun** (see also paper IAC-11-D5.3.3 Maiwald, Weiß, Jansen)

- CEF DLR Bremen: for instance - technology demonstration of solar-dynamic power generators, **s/c:** ~ 250 kg, **payload:** 1.5 kg, 2.5 W (FGM, particle+Γ+X+EUV monitor/telescope (Medipix), small optical camera) => 28 days solar originated space weather forecast time

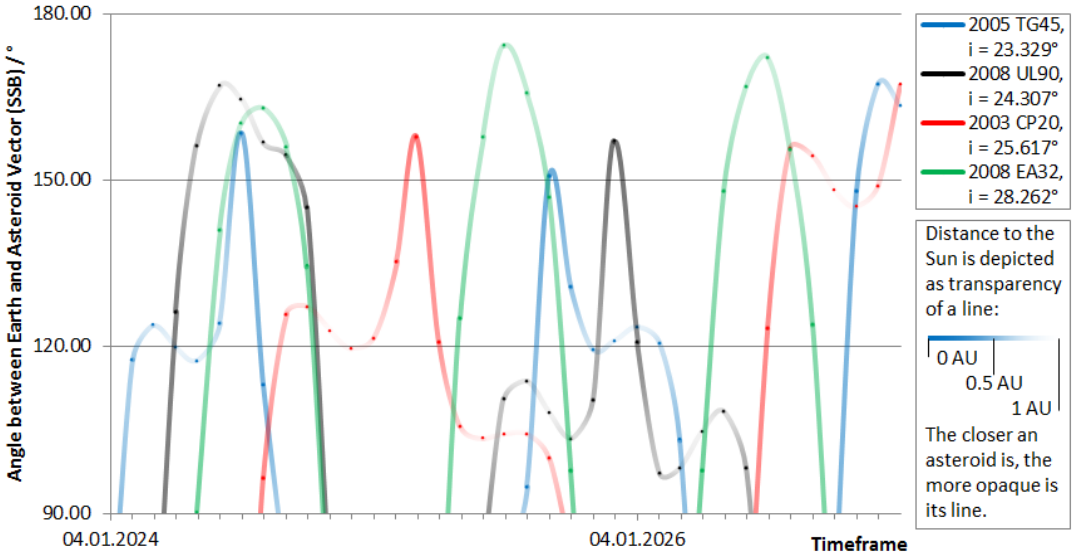




2) SPACE WEATHER OBSERVATION NETWORK (SWON)

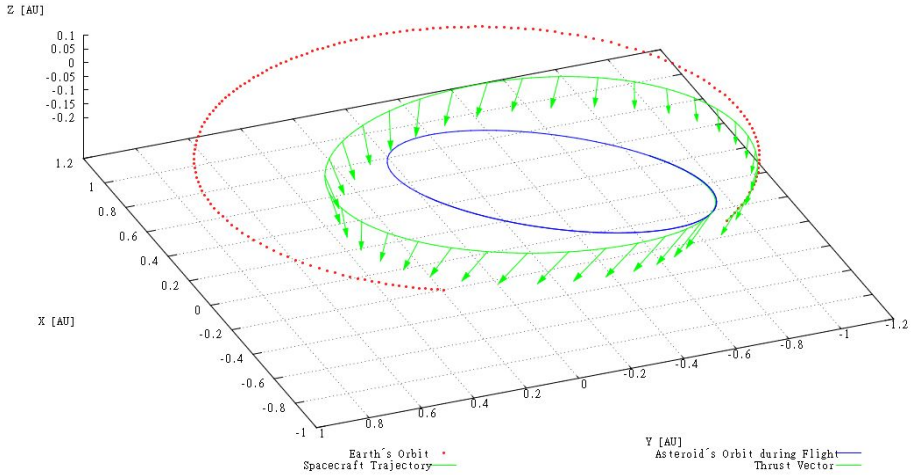
table: 10 know IEOs => fig.: angles between Earth and IEO asteroid as a function of time during a period of future solar maximum (2024 – 2026, passing Sun directly opposite Earth)

	Period[y]	a[AU]	e	i[°]
2003 CP_{20}	0.637	0.741	0.322	25.617
2004 XZ_{130}	0.485	0.617	0.454	2.953
1996 DK_{36}	0.576	0.692	0.415	2.017
2004 JG_{6}	0.506	0.635	0.531	18.945
2005 TG_{45}	0.562	0.681	0.372	23.329
2006 KZ39	0.475	0.609	0.541	9.925
2006 WE4	0.695	0.784	0.182	24.767
2007 EB26	0.405	0.548	0.786	8.461
2008 EA32	0.483	0.615	0.304	28.262
2008 UL90	0.579	0.694	0.380	24.307



2) SPACE WEATHER OBSERVATION NETWORK (SWON)

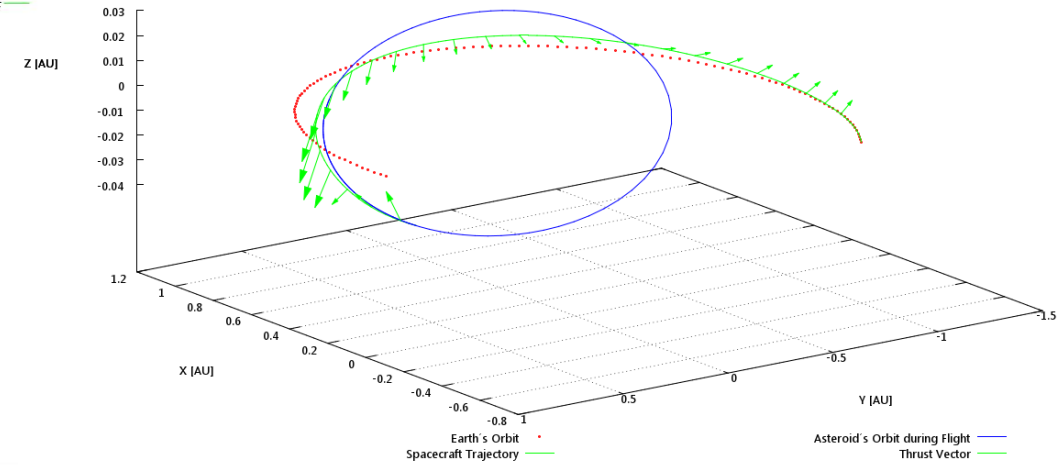
fig.: rendezvous trajectories targeting 2006 KZ_{39} (right) and 2004 XZ_{130} (left)
red - Earth's orbit, blue - asteroid's orbit, green – s/c trajectory with vectors for thrust direction



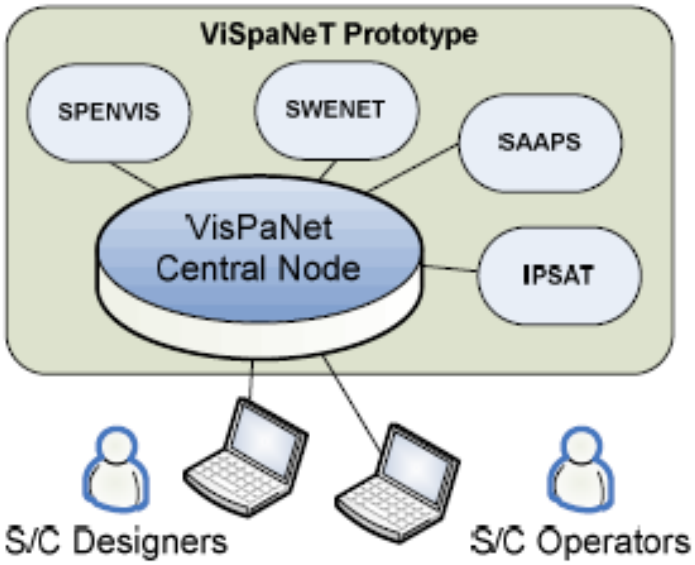
Main result:

optimization provides a rendezvous with 2004 XZ_{130} for late December 2024

International Participants?



3) ViSpaNet (Virtual Space weather Network of space systems)

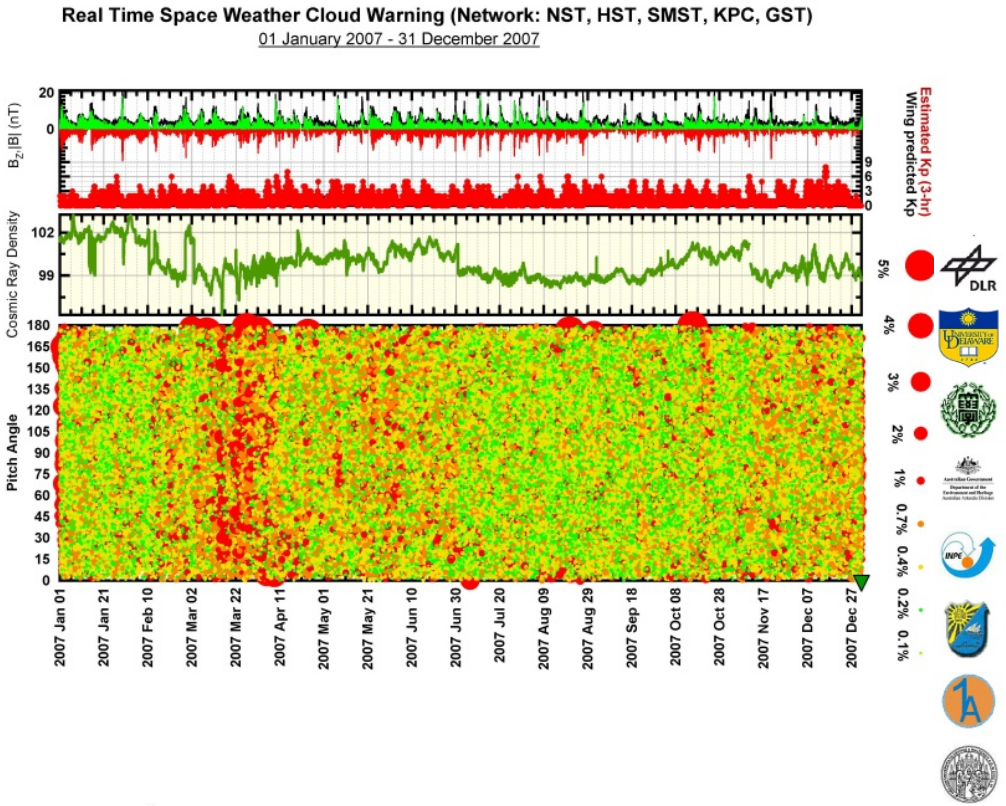


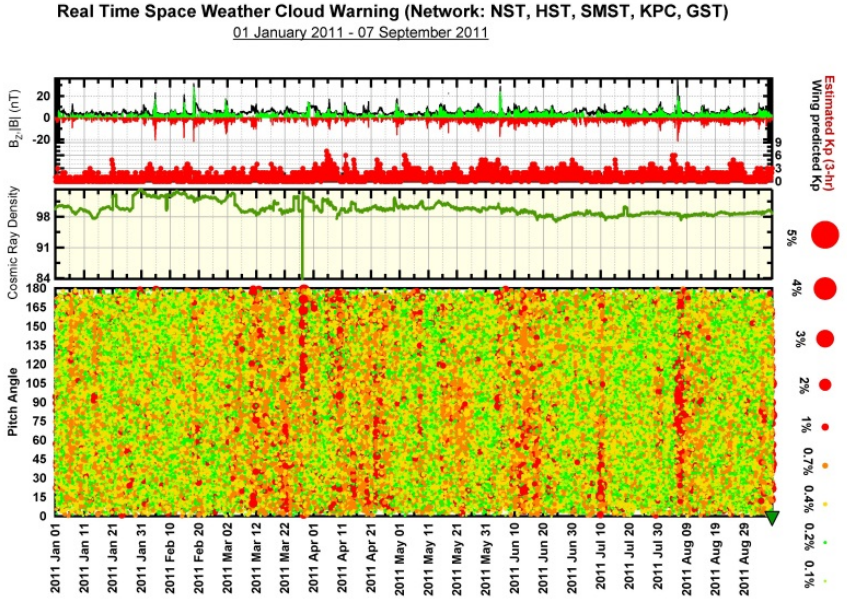
ViSpaNet (to be opened in 2012, wsdl):

- 22 use cases for s/c operators/designers, model developers and scientific community (GMDN data)
- analysis, nowcast, forecast/predict and real time monitoring and
- user can smoothly continue to work

4) **GMDN data, solar maximum** and Fukushima radiation

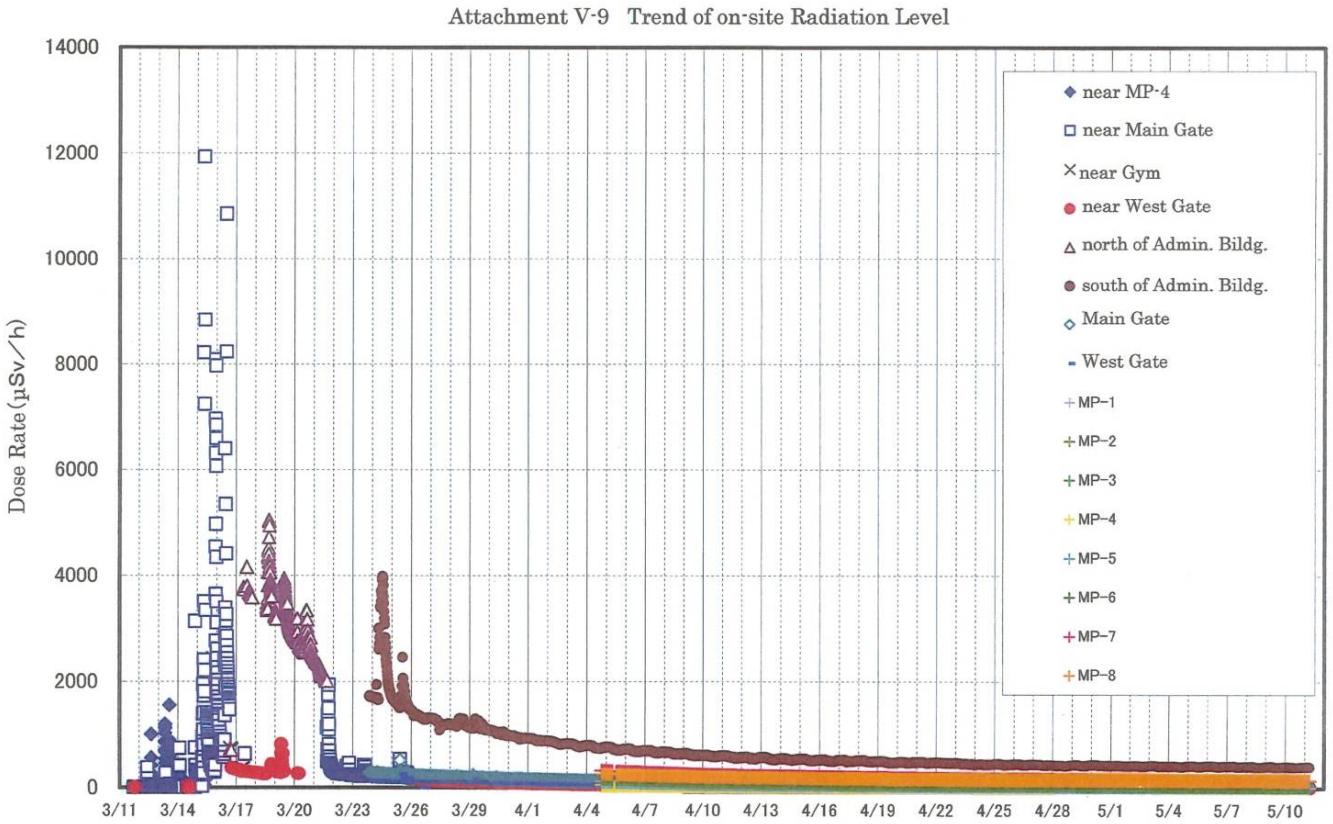
- GMDN – Global Muon Detector Network (international, ground based real time CR & CME telescope network)
- physics: cosmic ray anisotropy by CMEs, measured via secondary CR muons
- figure: left solar minimum (2007) and right solar maximum (begin, 2011) GMDN data (+ACE)





4) GMDN data, solar maximum and **Fukushima radiation**

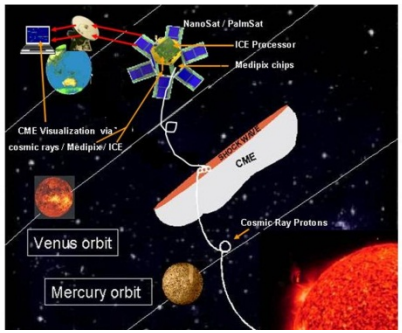
[a] Report of the Japanese Government to the IAEA Ministerial Conference on Nuclear Safety, June 2011

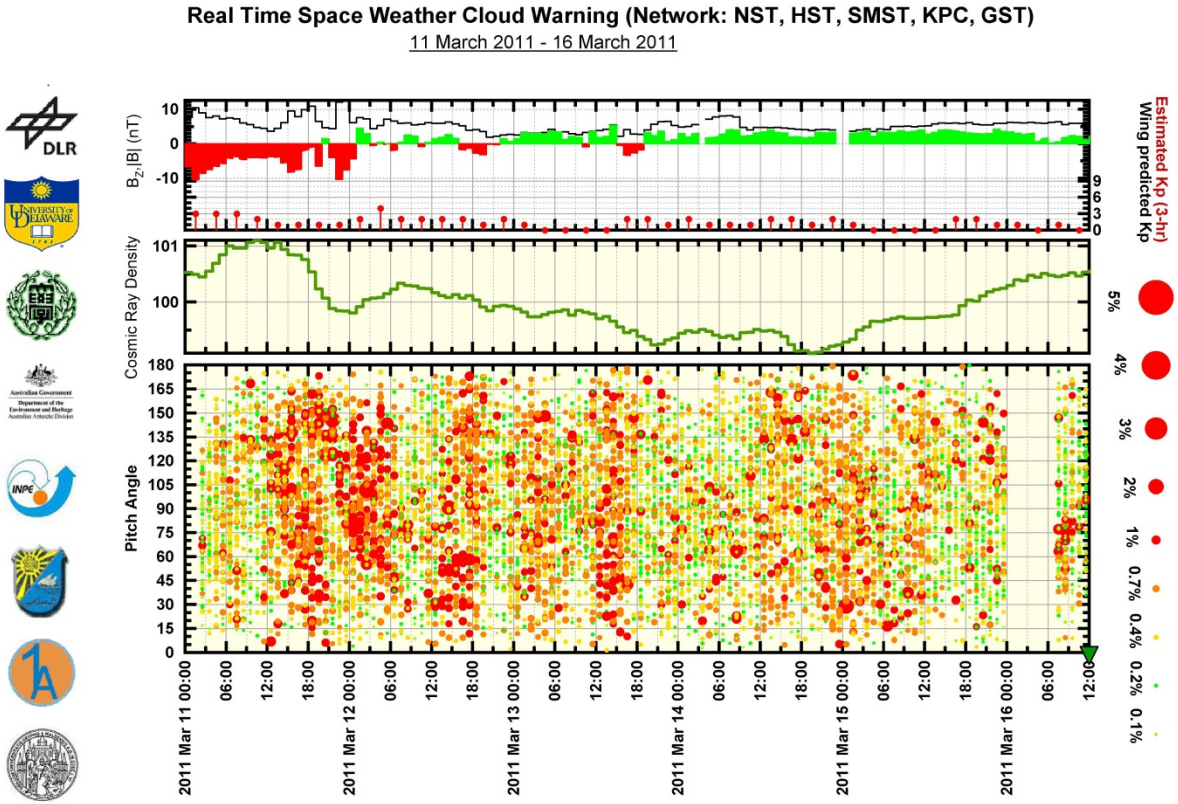


4) GMDN data, solar maximum and **Fukushima radiation**

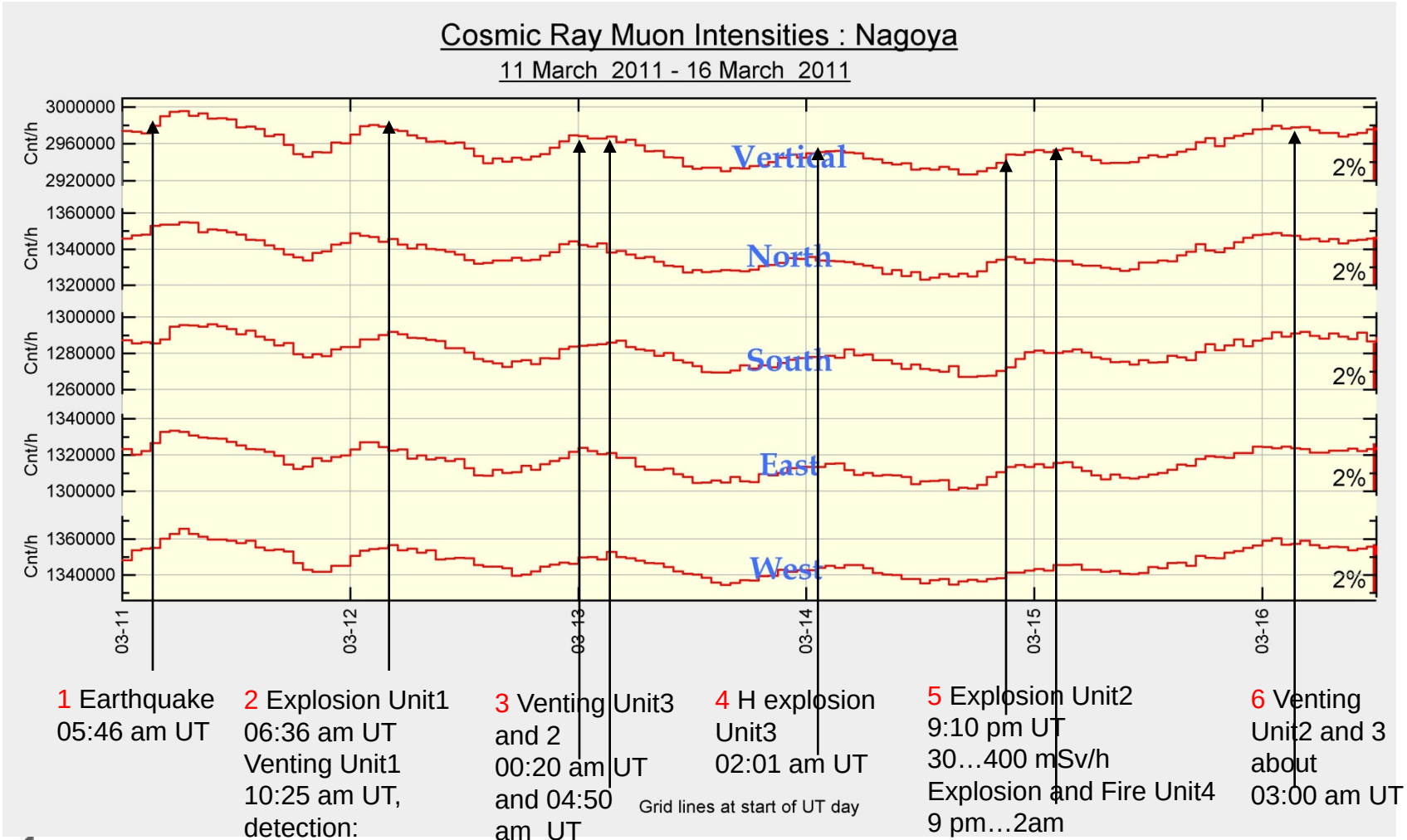
Observations: between **11 to 16 March 2011 only 1** of 5 GMDN telescopes measured **increase in CR muon counts** => this is the **Nagoya Scintallator Telescope** (NST has about 600 km distance from Fukushima-Daiichi (FD) nuclear power station (NPS))

Very „faint“ CME arrived at Earth (10 March 11), cosmic ray anisotropy due to NST (see next slide)?!





4) **GMDN data**, solar maximum and **Fukushima radiation**



1 Earthquake 05:46 am UT

2 Explosion Unit1 06:36 am UT
Venting Unit1 10:25 am UT, detection: ^{137}Cs and ^{131}I

3 Venting Unit3 and 2 00:20 am UT and 04:50 am UT

4 H explosion Unit3 02:01 am UT

5 Explosion Unit2 9:10 pm UT
30…400 mSv/h
Explosion and Fire Unit4 9 pm…2am

6 Venting Unit2 and 3 about 03:00 am UT

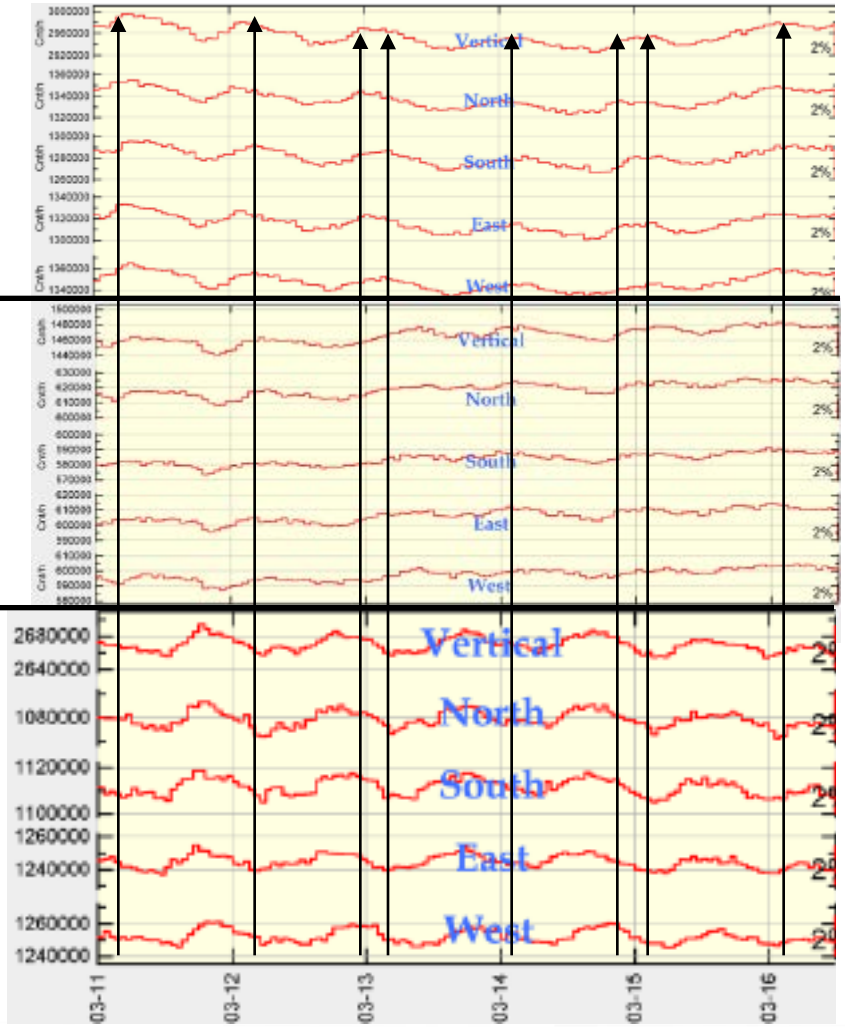
4) **GMDN data**, solar maximum and **Fukushima radiation**

Fukushima events: 1 2 3 4 5 6

NST (muon/h) at Nagoya / Japan

HST (muon/h) at Hobart / Australia

SMST (muon/h) at SaoMartinho / Brazil



Hints for correlations in time between Fukushima events and Nagoya muon measurements (favored: vertical and north direction?)?

No correlations in time between Fukushima events and Hobart / SaoMartinho muon measurements.

However:
diurnal CR variation effects?

4) **GMDN data**, solar maximum and **Fukushima radiation**

Facts: 1) fission product (FP) were plutonium in FD units,

2) early stage measurements[a,b] of **direct FP** (on 11/03/2011):

^{239}Pu = 3.2x10^{9} Bq (total of unit 1,2 and 3)

3) early stage measurement[a,c] of **indirect/radioactive decay chain product**

on 12/03/2011: ^{137}Cs = 1.5x10^{16} Bq (total of 3 units)

4) early stage measurements[a,c] of **indirect/radioactive decay chain product**

on 12/03/2011: ^{131}I = 1.6x10^{17} Bq (total of 3 units)

[a] Report of the Japanese Government to the IAEA Ministerial Conference on Nuclear Safety, June 2011
[b] NISA and JNES 4/4/2011: The 2011off the Pacific cost of Tohoku Pacific Earthquake and the seismic damage to the NPPs
[c] NISA have confirmed the presence of caesium-137 and iodine-131 in the vicinity of Fukushima Daiichi Unit 1 (http://www.iaea.org/newscenter/news/2011/fukushima120311.html)

4) GMDN data, solar maximum and **Fukushima radiation**

Fukushima facts:

1) $^{239}Pu = 3.2 \times 10^{9}$ Bq
2) $^{137}Cs = 1.5 \times 10^{16}$ Bq
3) $^{131}I = 1.6 \times 10^{17}$ Bq

Is there a HYPOTHESE: FD facts / NST Data?

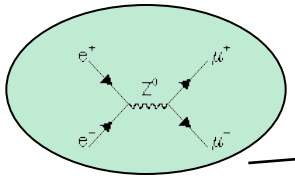
main fission chain: $^{239}\mathbf{Pu}$ (α,n) → ^{235}U → ^{129}I (β^- ($\mathbf{e}^-$)) but also $^{131}\mathbf{I}$ (with β^- => $\mathbf{e}^-$ producer)

secondary (from main) fission chain: $^{235}U + n \rightarrow {}^{236}U \rightarrow {}^{137}\mathbf{Cs} + {}^{96}Rb + 3\,n$
(^{137}Cs with β^- => $\mathbf{e}^-$ producer)

Big question: physics behind additional NST μ's from FD NPS?

a) normaly CME muons from $p_{CR} + p_{air} \rightarrow \pi^0$ but also π^-/π^+ with $\pi^-/\pi^+ \rightarrow \mu^- \mu^+$
b) from a) secondary μ^+ → secondary e^+ (plus primary CR e^+)

c) from FD NPS ^{131}I and ^{137}Cs with their β^- => FD NPS $\mathbf{e}^-$

d) 

1983 CERN Z^0 boson $e^-_{FD\ NPS}\ e^+_{secondary\ CR} \rightarrow Z^0 \rightarrow \mu^- \mu^+$ at NST measured

4) GMDN data, solar maximum and **Fukushima radiation**

Nagoya (NST) events: 1 (Earthquake), 2 to 6 (explosions / ventings)

1 Earthquake

Example: Antonova et al. Geomag. & Aeronomy 2009, No.6, 761-767

5.95 magnitude earthquake 25 Dec 2006 in Tien Shan, 2 detectors: 18NM64

=> thermal neutrons (~MeV, normaly from interplanetary disturbances**) increase (ΔI_n ~ 5%) with Earthquake start**, reason: escape of radon due to deformation of faults / or formation of microracks by (α,n) reactions from ^{222}Rn (α,n) ^{218}Po

No neutron monitor data in Japan during the period!

However NST muons (see also previous slide) and M9 Tohoku Earthquake?

^{222}Rn observation? Yes, indirectly via anomalies in TEC (Ouzounov et al. 2011 EGU Vienna):

Upper-atmosphere ionosphere=> the radon strips air molecules of their electrons, splitting them into the free electrons (TEC changes) and ions => attract condensed water in a process that releases heat (arXiv:1105.2841v1)

^{222}Rn (α,n) ^{218}Po **with free n** → p + e^- + electron-antineutrino

e^-_{Rn} $e^+_{secondary\ CR}$ → Z^0 → μ^- μ^+ at NST measured

=> **ΔI_μ ~ 1-2%** (NST cosmic ray muon anisotropy)

2 to 6 (explosions / ventings): **ΔI_μ ~ 1-2%** (NST cosmic ray muon anisotropy)

Summary

to 1) CR imaging and Medipix based telescope in study

to 2) SWON: asteroid 2004 XZ_{130} for late December 2024

to 3) ViSpaNet: a real time tool for s/c operators and designers
to be published in 2012

to 4) Hypothese about correlation of GMDN / NST and FD data

Education & Outreach

DLR_School_Lab in Bremen
Opening 24 May 2012

Real time cosmic ray muon visualization!

Universities of Nijmegen / Kiel